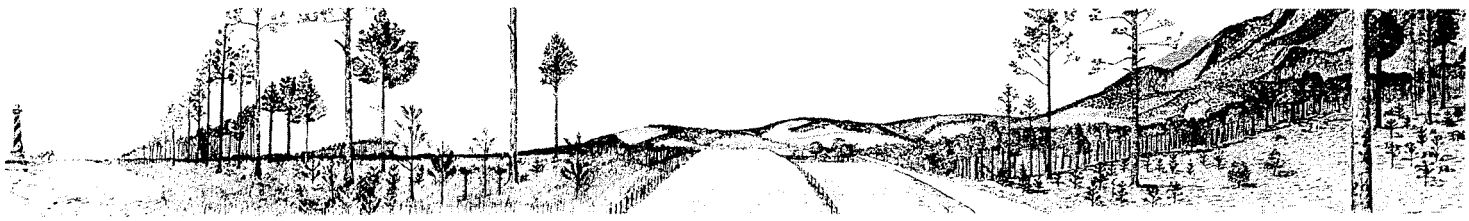

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GROWTH INTERCEPT AS AN INDICATOR OF SITE INDEX IN NATURAL STANDS OF WHITE PINE IN THE SOUTHERN APPALACHIANS

Abstract.--Equations are presented for estimating site index from periodic height growth in natural, even-aged stands of white pine in the Southern Appalachians. Site index can be estimated from height growth during both 3-year and 5-year periods, beginning with the year in which breast height was reached. In stands less than 15 years old, estimates of site index from 5-year intercepts are more precise than estimates from 3-year intercepts and are as precise as estimates from polymorphic site-index curves.

Wakeley (1954) has proposed that height growth for the 5-year period that begins when breast height is reached be used as an index of site quality for young plantations of conifers. This method, termed "growth intercept index," has a number of advantages over the conventional site-index approach. Among other things, this method eliminates the need to measure stand age, thereby saving considerable time and removing the error associated with age measurements. The intercept method also eliminates the need to measure total tree heights, which in closely spaced stands is often difficult and time-consuming.

Ferree et al. (1958) found the 5-year intercept to be a reliable indicator of height growth for the next 15 to 20 years in plantations of red pine (Pinus resinosa Ait.). They derived an index of site quality based on the 5-year intercept. Schallau and Miller (1966) later developed equations for estimating site index of red pine from 1-, 2-, 3-, and 4-year intercepts. Wakeley and Marrero (1958) found that 5-year intercepts were significantly related to total tree heights in plantations of southern pine up to 20 years of total age. The intercepts usually indicated the same significance or nonsignificance of the differences between site quality of paired plantations as were shown by total heights. Warrack and Fraser (1955) have reported that both 3-year and 5-year intercepts were closely related to site index in second-growth Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) and that they could be used for classifying site for general management purposes. On the other hand, Smith et al. (1960) concluded from measurements on 43 Douglas-fir trees that 5-year intercepts had less potential for predicting future height than did total heights at age 10.

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Eastern white pine (Pinus strobus L.) seems to be ideally suited to a system of site evaluation based on measurement of periodic height increment. These pines form a single whorl of branches each year, and examination of height-growth trends in natural stands of this species (Beck 1971) showed that differences in height growth exist between stands from an early age. Consequently, height-growth data from the previous study were used to investigate the relationships between growth intercept and site index.

METHODS

The data were obtained in 42 pure, even-aged stands of white pine distributed throughout the mountains of Virginia, North Carolina, Tennessee, and Georgia. The stands were free from evidence of disturbance by fire and logging or of damage from insects or disease. In each stand, three dominant or codominant trees were selected and felled for measurement. These trees appeared to have always been in the main canopy and showed no external signs of interrupted height growth.

The height attained at successive ages was determined by internode measurement. Because most of the stands were 50 years old or older, a direct measurement of height at age 50, that is, site index, was available. The range in site indices was from 71 to 122. The 3-year and 5-year intercepts on a tree were obtained by summing the lengths of successive internodes, beginning with the internode in which breast height was attained. The intercept measurements were averaged to obtain intercept indices for the stand. Measured 3-year intercepts ranged from 3 to 8 feet. Measured 5-year intercepts ranged from 5 to 15 feet.

Regression methods were used to relate average 3-year and 5-year intercepts of the stands to measured site indices. Although the ultimate aim was to estimate site index from measured growth intercepts, growth intercept was used as the dependent variable in the initial fitting of the curve. The inverse of this relationship was then used to estimate site index. This procedure was necessary because the stands were selected for specific values of site index and the values of growth intercept were then observed (Eisenhart 1939).

RESULTS

Scatter diagrams indicated that the relationship between both the 3-year and 5-year intercept and site index (S.I.) was nearly linear. Accordingly, the linear relationship was tested by regression analysis. The resulting equations were:

$$\text{3-year intercept} = 1.9 + 0.82\,(\text{S.I.}/10) \quad (1)$$

$$\text{5-year intercept} = 3.9 + 1.51\,(\text{S.I.}/10) \quad (2)$$

The standard error of the estimate for equation 1 is 1.04, with regression on site index accounting for 52 percent of the variation in the 3-year

intercept. The standard error for equation 2 is 1.56, with regression on site index accounting for 62 percent of the variation in the 5-year intercept. The prediction equations (i.e., the inverse of equations 1 and 2) are:

$$\text{Site index} = 23 + 12.1\ (\text{3-year intercept}) \quad (3)$$

$$\text{Site index} = 26 + 6.6\ (\text{5-year intercept}) \quad (4)$$

These relationships are graphically illustrated in figures 1 and 2.

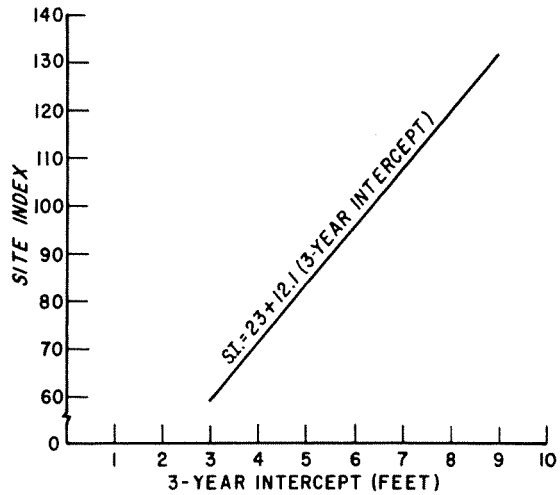

Figure 1.--Relationship of 3-year intercept and site index for natural stands of white pine.

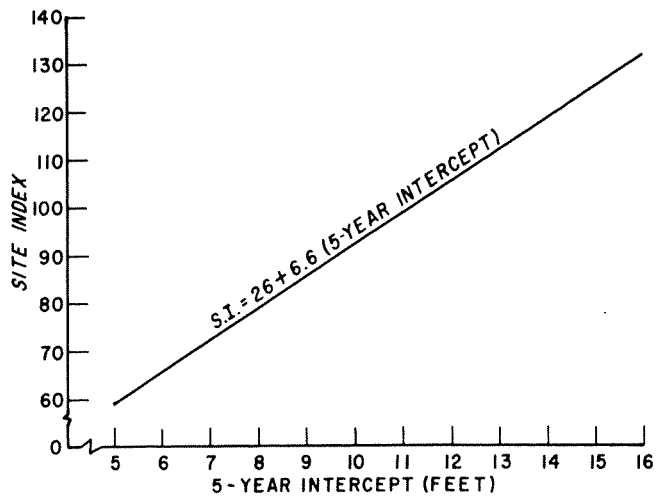

Figure 2.--Relationship of 5-year intercept and site index for natural stands of white pine.

Precision of the intercept equations was checked by comparing estimates of site index based on the 3-year and 5-year intercepts with the observed site indices of the sample stands (table 1). These results were then compared with the values derived when total height of the sample stands at 10, 15, and 20 years are used in connection with polymorphic site-index curves (Beck 1971).

Table 1.--Comparison of accuracy of estimated site indices based on growth intercepts and of estimates based on polymorphic site-index curves

Deviation from observed site index	Stands with site index estimated from growth intercepts--				Stands with site index estimated by site-index curves at--					
	3-year		5-year		Age 10		Age 15		Age 20	
	No.	Cumulative percent	No.	Cumulative percent	No.	Cumulative percent	No.	Cumulative percent	No.	Cumulative percent
± 10 feet	26	62	28	67	30	71	33	78	39	93
± 15 feet	6	76	7	84	6	85	7	95	2	97
± 20 feet	6	90	5	96	3	92	1	98	1	100
± 25 feet	2	95	2	100	3	100	1	100	--	--
± 30 feet	1	97	--	--	--	--	--	--	--	--
± 35 feet	1	100	--	--	--	--	--	--	--	--

As might be expected, estimates from 5-year intercepts are slightly more precise than those from 3-year intercepts. The longer growth period reduces the effect of one exceptionally good or poor year of growth.

In stands younger than 15 years old, estimates of site index from 5-year intercepts are about as accurate as estimates from site-index curves. Use of the growth-intercept method apparently reduces the effect of transient site factors such as weed competition; in very young stands, such factors may adversely affect total height and, consequently, the estimates of site index by conventional means. As stands become older, growth irregularities during the establishment period have less impact on total height. Consequently, in stands over approximately 15 years old, the intercept method does not give as reliable estimates as do conventional site-index curves.

APPLICATION

Application of the growth-intercept method for determining site index of natural stands of white pine requires only the measurement of the length of three or five consecutive internodes, beginning with the one in which breast height (4.5 feet above ground level) was attained (fig. 3). Measurements should be made on at least three dominant or codominant trees within an area of uniform site conditions; the sample trees should show no signs of suppression or breakage during formation of the internodes to be measured. The actual number of plots needed to establish site index in a given stand will depend on the variation of sites and the accuracy desired.

Estimates of site index can be made by entering equation 3 or figure 1 with the average 3-year intercept in feet or by entering equation 4 or figure 2 with the average 5-year intercept in feet. For example, a stand with an average 5-year intercept of 10 feet would have a site index of 92.

Figure 3.--The lowermost ribbon marks breast height. To determine 3-year intercept, measure from the node below breast height to the node indicated by the middle ribbon. For 5-year intercept, extend the measurement to the node indicated by the uppermost ribbon.

Although originally conceived by Wakeley (1954) as applicable primarily to young stands, the intercept method can be used in stands of any age as long as the nodes are visible. In stands younger than about 15 years old, as has been previously noted, estimates of site index with the intercept method should be equally as accurate as those obtained from conventional site-index curves. And, if one considers that errors in age determination have a large impact on site-index estimates by conventional means, the intercept method is probably more reliable in stands less than

15 years old. For many management purposes, the lowered accuracy in older stands will be offset by the time saved through elimination of the need to measure age and total tree heights. Also, in stands where total height has been affected by weevil attack, snow damage, etc., the intercept method may offer the only practical technique for determining site potential.

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